ELECTRICALLY ACTIVE TEXTILES AND ARTICLES MADE THEREFROM

FIELD OF THE INVENTION

The present invention relates to fabrication of electronic devices and circuits, and in particular to the integration of such devices and circuits into textiles.

BACKGROUND OF THE INVENTION

Electrical circuits are typically assembled by soldering active and passive electrical components onto solid boards. The components receive power and exchange signals by means of a network of conductive metal traces on one or both sides of the board. This approach to circuit fabrication, while virtually universal, nonetheless limits the manner in which electronic devices are housed and used. Generally, rigid boards are contained within an equally rigid cabinet, which sits on, or serves as, a piece of the user's furniture, or is instead mounted on an equipment rack. Indeed, the notion of electronics being packaged in "boxes" is so ubiquitous that alternatives are difficult to imagine.

But as the miniaturization of circuits continues, and as the range of materials from which electronic components may be formed expands, alternatives to traditional housings will assume increasing importance. In particular, much current research attempts to associate electronic circuitry more intimately with the user, so that its operation becomes a natural part of everyday action and routine. In this way, the user is spared the need to deliberately "operate" an external system, while the range of useful tasks amenable to electronic control or assistance is dramatically increased: environmental control, location monitoring, and exchange of information can all be effected without effort by the user or proximity to an external electronic device. In other words, by associating circuitry with the user rather than requiring the user to seek out the circuitry, the user need not interrupt or modify ordinary behavior to interact with electronics; instead, the electronics conforms to the behavior of the user.

Integrating electronic circuitry with clothing represents perhaps the most intimate (in the sense of proximity) and casual (in the sense of effortless availability) application of electronics to the everyday lives of individuals. While appealing, however, the idea of "wearable circuitry" remains elusive. People have long preferred the feel of woven cloth against the skin, conforming as it does to the human form and natural movements without discomfort. Directly integrating stiffly mounted electronic circuitry into traditional textiles would defeat their fundamental appeal.

Indeed, the characteristics of fabrics that render them ideal as clothing also offer advantages in numerous other applications. Fabrics can assume a wide variety of textures and appearances, as well as shapes and volumes; they are flexible, accommodate stress and movement without damage, and can be laundered. It is just these characteristics that traditional modalities for mounting electronic components lack.

DESCRIPTION OF THE INVENTION

Brief Summary of the Invention

In accordance with the present invention, fabrics are used as integral elements of electrical circuitry—to facilitate control over the operation of external components connected thereto, to serve as substrates onto which electrical components are connected, or as the electrical components themselves. Electronic textile devices can interact with users and/or the environment by, for example, touch- or humidity-sensitive elements, and offer the mechanical versatility and virtually limitless range of applications ordinarily associated with fabric. The textile devices of the present invention can be folded, rolled, or wadded up. They can be sewn into wearable articles of clothing, stuffed to form three-dimensional objects such as toys and sculptures, or stretched within a frame. Because the electrical devices are located within the matrix of the fabric itself, or may be conveniently removed if unable to withstand immersion in water or other unfavorable environment, the textiles of the present invention may be routinely washed without compromising electrical capability.

Accordingly, in a first aspect, the invention achieves selective, anisotropic electrical conductivity by utilizing conductive fibers running along one weave direction and non-conductive fibers running along the opposite direction. The conductive fibers serve as electrical conduits capable of carrying data signals and/or power, and may be connected, e.g., to electrical components soldered directly onto the fabric. A source of electrical power can be applied, for example, to a first end of selected ones of the conductive fibers, and electrical measurements taken (or signals read) from the opposite end. At one extreme, all of the fibers running along one direction are conducting, with the fabric structured to prevent inadvertent contact (and consequent electrical shorting) between adjacent conducting fibers. In this way, the fabric can be used as a high-density, high-capacity ribbon cable, with each fiber capable of receiving an independent connection; or as a high-density breadboarding facility to which electronic components can be directly soldered or adhered using electrically conductive adhesive (the latter option offering greater mechanical flexibility). For breadboarding applications, the fabric can simply be cut where signal lines are to terminate (e.g., between opposing pins of an integrated circuit).

Alternatively, the conductive fibers can be arranged in lanes, each lane comprising one or a series of parallel, adjacent conductive fibers, the lanes being separated from each other by at least one non-conductive fiber. This construction ensures greater separation between current paths, and affords relatively large contact areas for connection to components and terminals. For example, electrical connection to a lane of conductive fibers can be achieved by means of traditional fabric fasteners, such as snaps, zippers, studs, buttons, grommets, staples, conductive hook-and-pile materials, or hook-and-eye fasteners.

In another alternative, the conductive lanes can be strips of electrically conductive fabric attached to a non-conductive fabric substrate by, for example, an adhesive or stitching.

In addition to serving as substrates that receive electrical components and facilitate connection therebetween, such fabric structures can be used to control external circuitry. For example, two fabric panels can be overlaid with their conductive lanes opposed and crossing at an angle, the panels being normally held apart such that compression causes electrical contact between opposed lanes. Depending on the details of implementation, this construction can serve, for example, as a switch matrix or as a touchpad that senses the physical location of a user's contact. Either of these implementations is itself suited to a wide variety of applications. A switch matrix, for example, can have a surface design assigning a unique function to each of the lane crossings (e.g., calculator numbers, musical-instrument keys, etc.), with the fabric panels connected to external (or detachable) circuitry that implements the functions in response to user interaction with the panels.